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NOTES ON THE PSYCHIC DEVELOPMENT OF THE YOUNG WHITE RAT.

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A study of the psychic development of any young animal needs no apology. Apart from the fascination and the self-education of watching the development of any form of life from its early protoplasmic simplicity into complex maturity, there is the solid scientific reason that Genetic Psychology has much to hope from minute and accurate records of the developmental periods of young animals of all species. It may never be possible to reconstruct a complete psychic organism from the evidence of a single trait—an ideal borrowed from morphology—but something surely may be accomplished towards a *comparative embryology* of the soul. What Preyer and others have done for the human infant, needs to be done also for the baby-animal of every species. Prof. Wesley Mills, of Montreal, has already done this for the dog, cat, rabbit, guinea-pig and chick—which latter has also received careful study from Spalding, Morgan, Thorndike, Kline and others.

The present form of this study was suggested to me by Prof. Mills's very interesting and attractive work. I have adopted his method of giving the diary of the first few weeks of the young animal's life, substantially as the notes were jotted down, following this with a general summary of results and some inferences as to the significance of special features. For this purpose one litter of five rats was carefully observed daily, from birth to the age of four weeks. For study of special points and confirmatory evidence other litters were often used.

From a physiological point of view the developmental period of the human organism¹ falls into two great divisions—before and after puberty—the *ante* and *post urbem conditam* of growth. The pre-pubertal period is childhood. But this again is divided, upon physiological and anatomical grounds, into two periods, infancy (das eigentliche Kindesalter, *infantia*, *enfance*) and childhood proper (das Knabenalter, *pueritia*, *jeunesse*). Without pausing for the anatomical characters upon which this division is based, it is perhaps a fair statement to say that infancy is the period in the child's life before the neuro-mus-

¹ Vierordt: *Gerhardt's Lehrbuch der Kinderkrankheiten*, B. I, Ab. I, p. 299.

cular system and the sensory apparatus have reached a stage of development when they function easily and definitely. The period after that, and before puberty, is childhood.

In all the higher mammals, at least, there are analogous periods of development. Doubtless there are wide variations in the distributions of these periods, even between closely allied families as, *e. g.*, the guinea-pig and the rat. The guinea-pig's infancy is almost wholly intra-uterine,—he is born with neuro-muscular and sensory apparatus almost perfectly developed. The rat, on the other hand, does not reach a like degree of development until about the third week of life, or even later.

The diary covers the period of infancy of the white rat, *i. e.*, the period up to the time when the sense organs were working normally, and the muscular movements were all perfectly co-ordinated. The subsequent period has received only casual observation. The summary and inferences have the supplementary evidence of general observations covering a period of nearly two years.

Day 1. The rats at birth are bright red, ugly and helpless little creatures. The average weight is 5 grams. Average length: of body, 4.2 cm.; head, 1.2 cm.; tail, 1.4 cm. The skin is thin and delicate, and absolutely destitute of hair. There is no external ear—only a dermal fold. No external eye—a slight protuberance. The nose is pretty well developed—a spongy-looking bulb, armed with short delicate feelers. The nostrils are completely open, but very small—about $\frac{1}{2}$ mm. in diameter. Mouth is a mere sucking disk. No rudimentary teeth. Their movements, except sucking, are inco-ordinated, yet purposive. Sucking they accomplish lying on their backs and sides, the mother crouching over them. They keep constantly under the mother's body. When held in the hand they roll up in a ball. If placed upon their backs they hitch and kick and wriggle over upon the belly or side. They are generally unable to maintain the belly position for any length of time and fall over upon their sides in a ludicrous manner. When lying upon the belly, they stretch out their paws in a turtle-like way. Move their tails.

I distinguish three vocal efforts: a sort of clucking sound; a fine wire-like squeak (hunger?); and a sort of chirp, short and sharp.

I tested for reactions to smell, taste, and tactual stimuli.

Smell. 5 rats. All sensed violet, as indicated by expressive movements. Reaction, slow—about 15 seconds. One only objected: threw up head and made convulsive movements with fore paws. All showed dislike to cheese, if movement away could be so interpreted. Instantaneous convulsive reaction to HCl.

Taste. Tested with sugar-solution, warm milk, and strong salt solution. These were applied to lips with fine brush. In each case, the rats squeaked and wiped at the offending stuff with fore paws. Movements rather inco-ordinated. The movements are: brushing and pushing away with the fore paws; averting the head; movement of the whole body. In case of the salt solution, the reactions were more vigorous, accompanied by voiding of urine.

Clear water called out the same characteristic reactions.

From this similarity of response, I infer that there is no differentiation of tastes, as pleasant and unpleasant. They are all unpleasant.

Temperature. (a) They are very sensitive to atmospheric changes. Removed from the nest into a temperature of about 45° F., they become torpid; heart-beat becomes markedly slower and fainter. (b) They have temperature sense, though they do not respond to moderately hot or cold stimuli; a hot wire, just below burning point, makes them jump and wriggle within the skin; cold (water) above 40° F., gave no result unless accompanied by pressure.

Pain. They respond with squeaking and struggling to slight pinching.

Tactile Sensibility. They give little response to light pressure, as with a hair—except upon the nose, which seems to be very sensitive. Mass pressure is not noticed unless comparatively strong. All attempts to get response to sound failed—as expected.

Day 2. Repetition of the same measurements showed growth. Ear and eye regions a little more prominent. Seems to be slight advance in sense of smell, for they made no objection to odor of cheese. Other odors elicited same responses as first day.

Day 3. The movements are a little better co-ordinated. Only one of the five showed aversion to violet, and two to clove and asafœtida. Spirits of camphor and pennyroyal brought expressions of disapproval from all. Irritating fluid (HCl.) produced instantaneous responses from all. In addition to the motor reactions, there were vocal expressions and a striking acceleration of respiration. Reactions to the other stimuli were slow, varying from 10 to 50 seconds.

Day 4. The skin begins to whiten a little. Dermal sensibility seems about the same. Movements are better co-ordinated. When placed upon their backs, they turn over much more quickly and surely. Maintain position upon the belly. Are able to crawl a little, and to raise the head higher and longer than yesterday. They constantly utter short metallic squeaks and the clucking noises, during these efforts to recover equilibrium and orientation—for I take these attempts to raise themselves to be the prophecy of the orienting process. They huddle together—trying to crawl under each other. They make an animated pile. This is a characteristic habit of the rat throughout life. A company of rats will always pile up in a dense heap except in the warmest weather.

Smell. Reactions to violet, camphor, pennyroyal and clove, show less aversion; those to asafœtida are quicker and show more dislike. In four cases out of five there seemed to be a pleasurable response to cheese-odor—in one case accompanied by what sounded like a pleased squeak. The fifth one paid no attention. In case of camphor and pennyroyal, it was easy to distinguish between the act of sensing the odor and the affective response. They sensed pennyroyal quickly—about 5 secs.—sniffed with deep respiration—then slowly averted the head.

Day 5. Much stronger. Turn over almost instantly when placed upon back. Crawl with considerable vigor.

It begins to be apparent that the clucking sound spoken of several times before, is the beginning of a squeak—other than the one they make in the nest when hungry and which they make from birth. This new squeak is solider in timbre—a short, sharp, metallic click—something like the chirp of a sleepy chicken. It is evidently a sign of pain or discomfort. The other seems to indicate hunger.

Nothing new in regard to the special senses.

When returned to the cage they began immediately to crawl about in a lively manner. This is an infant prophecy of that restless curiosity which is so prominent a characteristic in the rat nature.

Day 7. Weight, 8.8 gr. A gain of 3.8 gr. Length: body, 6 cm.; head,

1.7 cm.; tail, 2.5 cm. The skin is now plainly covered with tiny white hairs. The ears, eyes and nose show commensurate progress. The pinnæ are 3 mm. in length; the invagination of the meatus begins to show. The membrane over the eye-bulbs is white, but shows a dark line where the separation of the lids is to be. There are a few brown hairs started. The nostrils have doubled in diameter. Feelers have more than doubled in length.

When placed upon their backs, they instantly turn over. Rest quite firmly upon their limbs, which are spread out in a turtle-like manner. Crawl vigorously.

Dermal sensibility becomes more acute, though susceptibility to pressure is still greater on the nose than elsewhere on the body. Especially, greater when tickling is involved. A bristle drawn across the body elicits scarcely any response; but applied with the same pressure to the nose, evokes squeaking and vigorous head-shaking. When the toes are touched the rats squeak and jump so as to lift the body nearly off the floor. One, thus insulted, crawled away two inches. There seems to be a slight intensification of the reactions to painful stimuli. I notice occasional convulsive leaps which have no apparent external cause. The tests for smell seem to show a growing indifference to all but the positively painful stimuli—irritating fluids, *e. g.*, HCl.

Day 8. Crawl vigorously. They almost crawled out of my hand before I realized what they were doing. In constant motion while on the table.

The nostrils begin to take on the pear-shape. Lower teeth can be seen in the gum, but are not cut.

When crawling about the table they show some selection of path, sniffing and going in different directions.

They seek constantly to get close together, each striving to get under the rest for warmth. This action is very striking.

Two crawled to the edge of the table, but stopped and then crawled away. Another one got too near, lost his balance and fell over. Another went to the edge and remained there with his head just over. This looks like a sensing of danger.

Reactions to odors become more individual. On the whole they tend to become indifferent. Glacial acetic acid and carbolic acid gave negative reactions.

Day 9. Pinnæ are 4 mm. long. Meatus deepening. Covering membrane of the eyes is now very thin, and shows dark purple in contrast with the surrounding white-haired region.

The motor activities are stronger. They move forwards, backwards, and sideways. Climb into a heap. One crawled more than a foot, stopped, hesitated and finally came back. They sniff constantly at everything. They crawled out of the nest after the mother had put them in. Saw one seeking purposively for her teats.

Day 10. Nostril is now perfectly pear-shaped. Feelers about 1 cm. in length. Mouth is assuming the adult form—the upper lip has the deep sinus.

Activities are stronger, better co-ordinated and more constant.

Special senses show no new features.

Day 11. Meatus-indentation shows corrugation.

Day 12. Lower teeth are cut.

Mother was at opposite side of the cage from the nest. One of the young ones crawled across to her and began to suck. He seemed to have a definite purpose. Later I saw the same one trying to crawl up the perpendicular side of the cage—wood covered with wire mesh. Got up about three inches before falling. A few minutes later he climbed

upon his mother's back. (N. B. Eyes not open.) They *walk* now, though rather unsteadily. By using both fore and hind feet they held to my hand a moment when I suddenly turned my hand half over. They also crawled out of my hand when it was gently closed upon them. A very characteristic action. Rats always squeeze through crevices if confined. I saw one washing his face—the real thing. Licked the paws and then carried them over the face. Repeated half a dozen times. Movements are not very well co-ordinated. Three crawled to the edge of the table, stopped, reached over as far as possible without falling, throwing up the head and sniffing in the very characteristic way of rats when orienting themselves, and then retreated. One leaned a little too far over, and fell, but caught the edge with fore paws and hung a moment till I saved him.

Dermal sensibility considerably heightened. One jumped violently when touched with the sharp corner of a piece of paper. Flanks, sides, back and feet are equally sensitive. (Possibly fright accounts for this violent reaction. But why fright, unless there is increased sensibility?)

Day 14. Weight, 14.8 gr. Length: body, 7.1 cm.; head, 2.2 cm.; tail, 3.9 cm. The *pinnae* are about 6 mm. in length; the *conch* is pretty well formed, and about 2 mm. deep. Ears and eyes appear ready to open. *Feelers* are 1.5 cm. long. The upper teeth are cut. The body is covered with hair about 3 mm. long on back and sides; shorter on the belly and legs. Ears and tail quite bare.

They run about the cage and over the mother's back. Climb over considerable obstacles. One got down from a block two inches high without falling. Hold on to the finger a second when turned upside down. All wash their faces industriously. When moved to a new place they go through the peculiar orienting movements of rising upon hind legs (as far as their deficient strength permits), lifting their heads and sniffing. They show the same proneness to pile up in a heap, when left loose upon the table. I notice also the convulsive starts, with no apparent external stimulus.

Sensibility is heightened, as indicated by convulsive reactions to tickling and light pricking. They sense odors at a much greater distance now. The same actions when they come to the edge of the table.

In their appearance and actions they now begin to answer to Dehne's characterization of "lieblichste Thierchen."

Day 15. Ear appears perfect, but is not open yet. So the eye.

They wash their faces frequently. Saw one scratch the back of his head and face with his hind foot. Romanes says this action is a pure reflex.¹ These movements were all perfectly co-ordinated. While I was weighing them, one fell out of the scale pan. He caught the edge as he went over and hung by his fore paws for more than a minute, struggling to get back, which he nearly succeeded in doing. A great increase in strength.

One of the rats crawled from the top of one cage down to another two inches below. The top of the first cage was walled in on two sides by glass sides, but at the corner where they met was an aperture about one inch wide.

The rat was crawling along the top of the box close to the glass side. When he came to the end he poked his nose through the aperture, discovered the descent, leaned far out and sniffed; tried to retreat, but, finding this difficult, sniffed carefully down the side, then went down without falling. Crawled an inch or two on the top of this cage,

¹ Darwin and after Darwin. Part II, p. 80.

then turned and came back the same way, climbing up over the first cage. (It is to be remembered that the rat's eyes were not open at this time.) The mental movement involved is not easy to interpret. One might speculate profusely. Whatever may have been the cause of his turning back, it seems probable that he took the straight path back by scenting his own trail.

Day 16. Ears and eyes not yet open.¹ The mother has roofed over the nest, and has a small hole for exit and entrance. I saw one of the young one's nose around until he found the hole and then crawl out. They can cling to the finger more than a minute when held upside down. They give no sign of fear when I handle them. They lie in my hand perfectly content.

Day 17. All have ears open and the eyes of all but one are wholly or partially open. (The eyes and ears of another litter opened on the fifteenth day.) This simultaneous opening of two new sense avenues must mark a crisis in the life of the rat. The voluntary motor activities noted are: crawling all over the mother while in the nest; frequent face-washing; occasional scratching of the head with hind foot; one nibbled at my finger as I held him in my hand; one crawled hastily out of the nest when I put my hand in to get them.

When being weighed, they crawled to the edge of the scale pan and peered over, but did not try to get out. I notice distinct tail movements. They now lie contentedly in a compact row instead of piling up indiscriminately. I am led to ask whether these huddling movements are not the first expression of the social instinct (after sucking and seeking the mother's belly for warmth). If so the desire for warmth is a primitive root of the social consciousness.

The rats now walk firmly and orient themselves quickly. I saw one chewing for several minutes, as if sucking or trying to swallow, as he lay half asleep. Is it a reflex exercise anticipating mastication? A play?

Sensation. Hearing. The bursting of a bag three feet away caused them to jump quite out of the nest. Later, clapping hands sharply at a distance of 10 feet caused the quick recoil peculiar to rats. Did not run. A sharp "sh" at 3 ft. brought their heads up. Word "rats" in a low tone at 1 foot, caused a slight jump. Rustling of paper produced the same result. Whistling brought up the head as if listening. Even at the very dawn of ear-consciousness there seem to be differences of emotional reaction to different elements in the "big buzzing confusion" around them. Every concussion elicits a startled movement; the gentle, prolonged note, *e. g.*, whistle, on the contrary, produces a reaction indicative of unscared attention.

Sight. When brought into a strong light they did not wink or show uneasiness, though they soon closed their eyes, and seemed to become drowsy. A stroke of the hand one inch in front of the face caused winking and a slight recoil of the head.

Smell. Recoiled quickly from camphor. Moved quickly toward brown-bread, dog-biscuit, and honey held at a distance of one inch. Appeared not to dislike iodoform or wintergreen.

Taste. One ate honey when a drop was put into his mouth. Tried to gnaw brown-bread when a crumb was put into his mouth. After that when the brown-bread came within smelling range he would go towards it. Chewed a tiny piece, holding it in his paws in a well-bred rat's way. I gave a little piece to another one. He took it in both paws and chewed it. The others scented it and tried to help, but he

¹ Another litter, having the eyes open already on the sixteenth day, lapped milk from my finger after having been given a taste of it.

quickly drew away with his treasure. There seems to be an immediate association between smell and taste. Though not conclusive, the evidence points that way. Another one declined to eat sealing-wax after smelling it, and spat it out when a piece was put into his mouth.

Emotion. They show fear, as before stated, when touched suddenly; also at a loud concussion. I cannot see that they have any fear of me, certainly not from smelling me. They looked happy when eating brown-bread.

Day 18. Eyes of all fully open. All the movements are stronger and are pretty well co-ordinated. They are sprightly and characteristically restless. They sit up well on their hind legs, using the tail for support, and wash their faces vigorously, passing the paws quite to the top of the head. (N. B., the first washings were almost farcical—the paws often not touching the face more than one stroke out of three.) One licked and gnawed at my hand as he sat in it. I put my finger near his nose. He sat up, took it in his fore paws and chewed at it.

They constantly run about the cage and cause the mother great anxiety by getting out of the nest after she puts them in. I saw them hiding, apparently, in the loose excelsior of the nest. This is the first thing I have seen that looks like play. They crawl all over the mother.

Their sense of equilibrium is pretty good. One crawled from one scale pan across to the other. The distance is about 2 inches, and the bridge not more than $\frac{1}{4}$ inch wide; and the two parts were oscillating at that. Yet he made the journey safely.

They begin to show the characteristic curiosity of rats—investigating with the nose everything they can reach. They jump occasionally without apparent stimulus.

I saw one licking another's face. Probably a play activity? Or it may be an instinctive outcrop of that reciprocal service of washing or vermin catching which rats perform so habitually.

Sensation. Hearing, acute. Convulsive movements follow clucking, "sh"-ing, clapping of hands and other sudden noises. Whistling causes only wiggling of ears.

Sight. Wink when any object is brought close to their eyes. When in a strong light they soon become drowsy.

Smell. Sensed moistened dog-biscuit at 4 inches. Sniffed at pure cologne water. This odor seemed to disturb them for they crawled about nervously for several minutes.

Taste. They chewed bits of moistened dog-biscuit with evident relish. Seemed to like sugar, but did not touch it until it was put into their mouths. The grittiness disconcerted them a little, but the pleasure of the taste seemed to compensate. Salt did not cause much disgust.

Emotion. They show fear at unusual noises. No fear of me. They lie contentedly on my hand, and are not afraid when I take them up. Stroking their heads has a soothing effect. They seem to get the greatest satisfaction from lying huddled together.

Day 19. Incessant activity after 4 P. M. Play with the excelsior of the nest; run over the mother and each other.

Gnawed at a big piece of dry dog-biscuit when I fed the mother.

They are still absolutely fearless with respect to me.

Day 21. Weight, 18 gr. Length: body, 8 cm.; head, 2.5 cm.; tail, 5 cm. In 3 weeks they have nearly quadrupled in weight, and doubled in length of body—tail quadrupled—head doubled. The mother escaped from the cage last night, so the young ones have not been suckled to-day. They huddled together quietly most of the day, but towards night

began to run about and play. I saw one drinking at the water jar. All ate hard biscuit, and lapped milk from a little jar as they sat in my hand.

Whenever I go near the cage they stretch up their heads and sniff all about. I put my hand into the cage, near the nest, and they all crawled into it and licked and nibbled my fingers. Not the slightest sign of fear.

They now go all over the cage—up the sides and crawl on the roof, belly upward. One went from the outside top of the cage down into the inside—a feat requiring very perfect muscular co-ordination.

They still prefer mother's milk to artificial food, as indicated by insistence on sucking the moment she returned to the cage.

They begin to chase and pommel each other. Saw one tugging at the tail of another.

Day 22. The sense organs are now perfectly developed. There is merely a continuous growth. Feelers, 2.5 cm. Hair varies from about 1 cm. on the back to less than 1 mm. on the ears and tail.

Activities. They play almost constantly while awake. Climb upon the mother and playfully bite her ears. Wash themselves a great deal. Are very neat. Wash the whole body and bite the toe nails. I saw one, this morning, digging very vigorously at the corner of the cage. He had dug away all the sawdust for the space of an inch. According to Groos's interpretation this would be a play activity. It would be interesting to know whether the rat was *trying to dig out* or *was merely digging*.

Emotion. Still show no fear of me. They crawl fearlessly into my hand and thence over my coat. One crawled from my shoulder into my pocket and remained there. Fear in connection with loud noises is more definitely determinable: besides the reflex recoil, they crouch and huddle together and wear a subdued expression.

Their curiosity is inordinate. It seems greatly to predominate over fear—in striking contrast with the adults where the balance is pretty evenly preserved.

They come towards me whenever I open the cage. I am not quite sure whether they see me approaching, but I think they do.

They sleep most of the day, and still suck a good deal.

Advancing intelligence was marked to-day by a rat's pushing a comrade away from the dish of milk. The stimulus to this action might have been the odor or it might have been seeing the other fellow drink. The movement was very effective. Intelligence in this case at least is a "means to nutrition."

Day 23. The plays become a little more definite. The rats nip each other's tails, ears and feet. No real scrimmages as yet. They also lick each other—as if affectionately fondling each other.

The mother was returned to the cage after an absence of 24 hours. The little ones all left a dish of warm milk and hastened to suck. They exhibited the greatest satisfaction in the change.

Something to-day that looked like imitation. The mother was sitting in the nest, pulling excelsior towards her to build up the nest. One of the little fellows suddenly began doing the same thing. Stopped when the mother stopped.

They also began trying their teeth on the wood of the cage to-day.

Day 24. They now struggle for food. Begin to show the greedy eagerness which is a marked characteristic of the adult rat. I saw one scuffling with the mother for a piece of biscuit.

One ran and hid behind the mother when I put my hand into the cage. I have not seen, before this, any show of fear at the sight of my hand—or was it play—mere pretence?

They have fierce sham fights, tumbling, rolling and leaping about, but I have not seen any display of anger. They come to the window when I tap on it; and stand in attentive attitude after the reflex recoil at the sound. They dig into the corners of the cage a great deal. I also observe them "picking" the mother and each other a great deal. This seems to be recognized as a reciprocal office, for they sit quietly while it is being performed. Vermin?

Day 25. Play is very vigorous. They frequently start and leap without the least external stimulus—apparently the mere discharge of superabundant motor impulse. Frantic rushes up the side of the cage. They fight beautifully for food, but no sign of anger.

Day 28. The rats are very active. They play incessantly while awake. At this stage they are veritably "lieblichste Thierchen"—most fascinating little creatures. Their rapidity of movement is marvellous. The plays certainly cover a great many of the serious activities of adult life—including those of sex. They show no striking fear of me yet. Occasionally they run away after sniffing my hands, but this seems to be as much in sport as in fear.

REMARKS ON THE DIARY.

Prof. Mills, in his remarks upon the psychic development of his puppies, says: "The facts most striking in the first few days of life are the frequent desire to suck, the perfect ability to reach the teats of the dam just after birth, the misery evident under cold and hunger, and the fact that the greater part of existence is spent in the sleeping state." This statement is equally true of the young rats, if we add the facts of their rapid growth and change from the larval appearance, and of their vocal accomplishments. The desire for warmth and the desire for food seem to be their very first psychic experiences in life; the former preceding in time and being more imperative. A special significance of this fact will be noted later.

SUCKING. Prof. Mills discusses fully the first character of this reaction, and concludes that it is not a "congenitally perfect or instinctive action" as the "sucking is not perfect at first," but "is improved with practice." My observations upon the young rats accord perfectly with the conclusions of Prof. Mills. The young rats find the teats largely by accident, aided by the mother who pushes and pulls them under her. I have not seen them attempt to suck other parts of the mother's body—the fur, *e. g.*,—as did Prof. Mills's puppies.¹ I am also of the opinion that smell plays no very important part in finding the teats at this early period. It is rather that they are attracted by the warmth of the mother's belly and find the teats accidentally.

SENSATION. The infancy of the rat falls naturally into two distinct divisions: the period before the opening of the eyes and ears, and the period following this event. As noted in the diary the ears and eyes open almost simultaneously, from the

¹ Since writing this sentence I have seen a six-days-old rat sucking the mother's fur.

fifteenth to the seventeenth day. Before that time, taste, smell, the dermal and tactile groups, and the organic sensations are present.

Pain. The young rats experience pain from the very first—a slight pinch or prick or extreme heat bring out pain reactions. If one may judge, however, from the relative violence of reactions, sensitiveness to pain is much less acute at first than later.

Taste. The experiments seem to show that there is little or no discrimination of tastes at first. The reactions indicate that all tastes, except the taste of mother's milk, are disagreeable—some more than others, of course. It is possible that taste, properly speaking, is absent at first, and that the temperature, and the chemical and mechanical effects of the substances determine the reactions. The apparent disagreeableness of so many substances lends color to this supposition. Experience of sensations inherently pleasurable may be needed to neutralize the disagreeableness of the primitive shock.

Smell. Though taste and smell are intimately connected, it is comparatively easy to eliminate the taste element from the experiments on smell. It is certain that the young rats can sense odors immediately. The strong irritating fluids like HCl. produce, of course, a direct chemical effect upon the mucous membrane. This is positively painful, and the reaction may be regarded as the indication of a pure pain sensation, in spite of the genuine odor-element in this stimulus; but the reactions to other odors which are quite free from the irritating element prove beyond a doubt that the pure sense of smell is present at this early period. Whether there is discrimination of smells at first is doubtful. When three or four hours old the rats react from violet and cheese in about the same way, indicating that all odors are disagreeable at this time. This state continues for a day or two; then the rats begin to show discrimination. They turn away from some odors as if in disgust, approach others with something like satisfaction, and are apparently quite indifferent to others. This character of indifference extends to a larger field of odors as the rats get older. It is easy to distinguish between the act of sensing the odor and the affective reaction, though at first this is less easy. In the case of irritating fluids such discrimination is impossible, for the reaction to the stimulus is instantaneous. With pure odors, however, even from the first there are movements,—adjusting the head and sniffing—indicative of sensing, which precede the movements expressive of pleasure or disgust. After the first few days the careful sensing of the odor before the affective reaction is clearly marked.

These facts are what might be expected from the anatomical character of the olfactory apparatus. The nose and olfactory

lobes are well developed at birth; but there is every reason to believe that the psychic results of this first functioning must be of a very general character. The machinery is all ready, but, like any other piece of new machinery, it needs use and oil in order to attain its maximum efficiency.

There seem to be considerable individual differences in regard to the smell sense at this early period. Some manifest indifference to most odors much earlier and more definitely than others.

As the sense of smell is the rat's psychical organ in food getting, we should expect to find the young rats developing the sense in the following order: (1) the initial stage of extreme sensitiveness, when all olfactory stimulations are displeasurable; (2) an intermediate stage, when all but positively detrimental stimulations are indifferent; (3) a period when there is developed discrimination of those odors associated with food from those not so associated. As a matter of fact, there is some such order as this. The stages are not marked, of course, by hard and fast lines; but the evolution from the first undifferentiated nose-consciousness to the point where food-stuffs and odors are definitely associated shows these phases. The process, however, is not entirely one of experimental association, through taste. The young rats show interest in the odors of cheese and milk, *e. g.*, long before they have tasted them.¹ On the other hand they are indifferent and even averse to the odors of many substances without ever tasting them. This selective faculty must be referred to the inherent character of the rat's nervous substance out of which is developed this psychic faculty by normal functioning.

One other question with regard to smell is suggested: have rats any pleasure in odors apart from their association with food? do odors arouse in them purely æsthetic feelings? There is no *a priori* objection to this supposition. It is well known that rats have an æsthetic sense with respect to hearing. I am convinced, too, that rats manifest curiosity apart from that curiosity which is directly associated with nutrition and reproduction. The analogies of these faculties are favorable to the view. Furthermore there is no valid objection from a strictly selectionist point of view, as the mere euphoria resulting from æsthetic olfactory sensations would certainly have a salutary influence in the vital struggle. Of positive evidence there is little. Darwin says that "rats are attracted by certain essential oils," but gives no hint as to the particular oils which have this power of attraction, so we do not know whether they

¹The odor and taste of cold cow's milk are not identical with those of warm rat's milk.

are food-oils or otherwise. My own experiments have given no definite results either way.

DERMAL SENSATIONS. The young rats, from the first, respond to tactal stimuli. The temperature sense is well marked at birth. I am not so certain about the special tactile sensations.

Temperature. The temperature sense must not be confused with sensitiveness to atmospheric temperature. The psychosis in the latter case is a result of the condition of the whole organism, in which the vital processes are retarded and sensations of general organic discomfort are felt. The temperature sense is, of course, a dermal function merely, and is local in its scope. At birth, a hot substance, just below the burning point, produces a quick reaction; likewise any cold substance at about the freezing point.¹ Between these two extremes, I could get little or no reaction to temperature stimuli. It is impossible to test this sense after hirsutation, so I do not know whether there is an increase or decrease of acuteness. Sensitiveness to cold, however, decreases in ratio to hirsutation, though the white rats can never endure a low temperature.

Pressure, Tickling, and Mere Contact. These factors are too closely connected to permit separate consideration. At birth, light pressure, unaccompanied by motion, produces no reaction, especially if the pressure be exerted with a small body. Comparatively light mass-pressure elicits reaction. So far as I have been able to see, mere contact does not. Tickling, by drawing a hair over the body, produces little effect—often none at all if the pressure element is eliminated, but the same stimulus applied to the part of the nose where the feelers are, elicits a decided negative response. The acuteness of this group of sensations increases *pari passu* with the advance of hirsutation.

EQUILIBRIUM, SENSE OF SUPPORT, AND ORIENTATION.
Equilibrium. The young rats from birth have a rudimentary sense of equilibrium. All their movements, inco-ordinated and ineffective as they are, show a preference for the belly position. If placed in any other position they strive to regain this one, and are not comfortable until they get it. (An exception to this is, of course, the tendency to lie upon the back when sucking, but that is a special office demanding special position.) The neuro-muscular mechanism, however, is so imperfectly developed at this period that effort is required constantly to maintain the normal position. By the end of the first week they are able to equilibrate pretty well, and before the end of the third week they maintain their balance under the most

¹There is a possibility that what seems to be temperature sensation is pain sensation—but the temperatures tried are well within the normal limits. It cannot be mere contact, for similar contact at mean temperatures effected no reactions.

trying circumstances. I have made no tests to determine their susceptibility to dizziness, but have no reason to doubt that it is present from the start.

Orientation. This view of dizziness finds some support in the fact that they orient themselves with respect to up and down from the very first. I have not made any test to determine at what least angle they turn the head to the upward inclination, but certainly they do so at 30° . The adjustment is comparatively slow at first, but becomes instantaneous before many days.

I am of the opinion that there is a rudiment of lateral space orientation from the first. The new-born rats when placed on their backs struggle over on to their bellies. With the normally strong rats this effort is generally succeeded by an attempt to rise upon the legs. At the same time the head is stretched upward. Now this is the incipient stage of the characteristic orientation movement of the adult rat—rising upon hind legs with the tail as extra support, describing a circular movement with the head and sniffing all the time. As early as the fourth day these movements began to take on some definiteness, and by the seventh day they are associated with the selection of path and the avoidance of obstacles when the rats were crawling about. In view of the relatively unimportant part that sight plays in the life of the white rat—and probably of the rat in general—the relatively perfect orientation in this way, long before the opening of the eyes and ears, is significant. As recorded in the diary a rat on the 11th day crawled directly across the cage to the mother—a distance of eight inches, and began to suck. This was six days before his eyes were open; and on the 15th day, two days before the eyes were open, one performed the difficult feat recorded on page 84. Now, as the same movements are used in orientation after the eyes and ears are opened, as before, one is led to conclude that the influence of the eye in the orienting process is very slight. The neural paths which are blazed out in this pre-visual state are the paths that continue to be used. If this is true it suggests two important principles in the study of comparative psychology—even when made experimentally, viz.: (1) the necessity of knowing your animal before you try to enter into experimental conversation with him; and (2) the immense differences in mental processes between not only the lower animals and man, but equally between different animals. The difference between the eye orientation of man and the nose orientation of the rat is not more specific than is that between lynx and rat.

Sense of Support. This phrase is suggested by Mills and commended by Morgan. Mills uses it to describe the sensation which land animals feel when they are deprived of a solid foun-

dation,—as, *e. g.*, when his puppy or kitten stops and shows uneasiness at the edge of a table. Mills thinks this sense is peculiar to land animals, and is congenital—a character which has been acquired since leaving aquatic life. The amphibious turtle, he remarks, will walk right off a table without any apparent sense of the difference of medium.¹ All young land animals, on the contrary, show hesitation when they approach a void; and even though they may be going too fast to stop, they yet make an effort to save themselves. Prof. Mills does not, of course, regard this as a simple sensation—but rather a feeling-complex of various dermal and organic elements. I do not see why it is not a lower stratum of acro-phobia (the fear of falling). My observation of the young rats is confirmatory of Prof. Mills's view. As early as the second day they show an uneasiness when on the edge of a void—sometimes drawing back, sometimes manifesting their dominant trait of curiosity by leaning over and sniffing. At the age of four or five days the presence of this sense is unmistakable, and is not due to experience, as I have found by trying rats that have had no such experience. I had noticed this phenomenon before reading Prof. Mills's remarks on this subject. His interpretation seems to be more satisfactory than anything I had thought of, though, as he himself points out, the case is not completely made out.

SIGHT AND HEARING. The eyes and ears begin to function the fifteenth to seventeenth day, different litters presenting this range of variation. The individuals of the same litter also present variations of several hours in some cases. (Every factor in this development-history seems to emphasize the frequency and range of congenital variation.) At birth there is no external ear—only a dermal fold—the incipient pinnæ. This begins to unfold from the front backwards about the second day and is at first semicircular in form. It attains its perfect form and a length of 6 or 7 mm. just before the meatus opens. The meatus indentation is seen first about the eighth day and assumes its perfect form at the same time as the pinnæ. The growth of the eye is analogous. All attempts to get reactions to sound or light before the opening of the ears and eyes failed. Even a powerful concussion near the ears was effectless. I regret to say that I did not try the effect of a powerful light close upon the unopened lids.

Sight. The question of what the young rats see is complicated by the question of what the adults see. The actions of the adult rats seem to indicate that they see motions rather than objects. I do not mean that they do not have images of objects, but rather that the images of motionless objects have

¹ But will a land tortoise?

little compelling power upon their attention. They follow a moving object with their eyes at a distance of several feet, but they always make their investigations of motionless objects with their noses. I made tests upon the young rats a few hours after the opening of their eyes. They showed some slight discomfort in a strong light, soon closed their lids and seemed drowsy. Throughout life, the white rats show a decided aversion to strong light. I infer from this fact, and the special signs of discomfort, that the first light stimulus is positively painful. The limit of vision is restricted at first. The eyes do not follow a moving object even at a distance of a few inches, and a winking reflex cannot be produced without almost touching the eye. The inference is pretty clear that the first eye-sensations are brightness-sensations and that the eye requires time to adjust itself to the new conditions; in a word, it is not functionally perfect, though it may be anatomically perfect.

Hearing. The ear is hyperæsthetic at first. All sounds—even very slight ones—elicit rather exaggerated responses. The bursting of a paper bag and the clapping of hands at a distance of ten feet, and the gentle rustling of paper at one foot, produced strongly marked reactions.

The rats discriminate between sounds, however, at this time. For instance, a gentle and prolonged whistle produced only a lifting of the head, as of attentive listening, whereas the hissing syllable "sh" caused terrified leaping. It is impossible to say whether there is complete discrimination between tones and noises, but all concussions call out the reflex jumping. I am of the opinion that intensity is more important than quality, at this time, in determining the reaction. Nevertheless, the observed facts in regard to the musical sense of rats and other varieties of the *muridæ*, prove that intensity is not the only factor determining their likes and dislikes. Not only have they a well developed æsthetic sense in respect to tone, but they also regard quality as well as intensity. It may be, therefore, that there is in this case, qualitative discrimination *ab initio*—or as soon as the "big buzzing confusion" has subsided a little.¹

As smell is the rat's psychical organ of food-getting, so is

¹This is a point which I have not studied carefully. Yet it is important, for it opens up the whole question of the æsthetic nature of the sub-human species. The data upon this subject are abundant but anecdotal. An ontogenetic experimental study of the musical sense of a few of our common animals could not fail to let in light upon the meaning of the æsthetic sense. The Darwinian interpretation seems inadequate. Sexual selection does not account for all the facts. Prof. Everett's suggestion as to the selective value of mirth, as a promotor of well-being, and hence an aid in the struggle for survival, may be applicable to this question as well.

hearing his psychical organ of defence. The initial hyperæsthesia of hearing means simply that the organism responds reflexly to these unwonted stimuli. It is instructive to note that at first these reflex recoils seem to produce little psychic effect (either perceptual or emotional). There is a motor explosion, and almost instantly the rat resumes his wonted attitude and occupation. Gradually, though rapidly, there is a change in all this, and the reflex recoils are followed by attitudes denoting fear or attention. The attentive attitude is very like that noted at first in response to whistling—the head lifted, etc. The fear-attitude is easily recognized. Later, other emotional states appear, concomitant with auditory stimulation. This indicates a rapid integration and functioning of the higher centers and the associative tracts, which at first are not functionally perfect. It is an analogous case with that of the sense of smell—with the difference of the post-natal anatomical perfecting of the auditory apparatus.

INSTINCTIVE ACTIVITIES. I shall confine my remarks upon this point, to a discussion of the question whether instinctive activities are congenitally perfect. This question, however, has been involved in so much confused and confusing dogmatism and speculation that I must pause to state clearly the limits of the question. Much of the dust stirred up by the various champions might have been avoided had these champions been clearer of their own meaning. The first and most necessary delimitation is to separate sharply the field of instinctive activities from that hypostatic entity known as instinct. This is seldom done; and, indeed, for some purposes it is unnecessary. Prof. Groos, *e. g.*, writing of Play, first elaborates a metaphysical notion of instinct, basing it upon a natural selection teleology; he then forces into an *omnium gatherum* all the voluntary movements of young animals and calls them plays; and then informs us that play is an instinct. Prof. James likewise includes under his category of instinct a quite heterogeneous group of psychic characters. For purposes of teleology and classification this procedure is very well. On the other hand, in a genetic study of instinctive activities the mind must be rigorously on guard against the intrusion of this metaphysical concept of instinct. The necessity for this will be apparent when we consider that two such remotely related phenomena as fear and the bridal flight of the bee are equally "illustrations of instinct." For the purposes of psychological inquiry, the only assumption we need to borrow from this hypostasis of instinct is that of its non-experiential character. All agree that an instinctive activity is one that is performed by an organism without previous experience. In psycho-physical terms, it is the impulse, the effort of an organism to act, with-

out previous experience, in a certain, definite, purposive way, under certain definite conditions. The range is therefore very great. But as "impulse and effort of an organism" are actualized only in motor terms, the instinctive activity is also conditioned by the neuro-muscular mechanism. A tentative definition might be then: an organic impulse, effecting through the neuro-muscular system, definite, purposive, motor ends. The question of the congenital perfectness of the instinctive activities is, therefore, a question of the functional perfectness of the neuro-muscular system at birth. If the neuro-muscular system is so co-ordinated and determined as to realize immediately and certainly the behest of the organic impulse, then the instinctive activity is congenitally perfect; otherwise, not. This means that in most cases instinctive activities are not congenitally perfect. Almost always the perfect instinctive activity is the congenital *set* of the organism *plus* the accuracy and definiteness of movement gained by exercise of the function.

In this view the young rat exhibits almost no congenitally perfect instinctive activities. Crying, which begins at birth, seems to be an indisputable case; also the sucking-reflex—not the complex of movements involved in sucking. All the other activities are inco-ordinated at first, whether manifested immediately after birth or only at a later time. I have set down the following as clear cases of instinctive activity under the provisional definition: Sucking, swallowing, chewing, crawling, clinging, climbing, digging, gnawing, washing, scratching (with hind foot), running, leaping, sex-movements (in play), and, possibly, the "picking" and licking noted in the diary. None of these are capable of immediate and perfect action at birth; some do not appear until several days or weeks after birth; yet all are clearly organic impulses in origin. Several may be called pure reflexes, but the evidence is not clear except in the case of sucking.¹ The face washing is an instructive example. The neuro-muscular mechanism necessary for this act is approximately perfect at birth, as proved by

¹ Prof. Romanes's attempt to prove that scratching with the hind feet is a pure reflex is inconclusive. His method was to amputate the hind feet of his subjects soon after birth, before the appearance of the activity in question. He found that the movements were performed in due time by the mutilated rats just as by the normals, though they were perfectly ineffective. The stump was merely waved in the air, never once touching the irritated spot. This demonstration is imperfect for he did not carry his experiments far enough to determine whether the rats would learn, in time, the uselessness of the movements and cease making them. Moreover, in order to make this demonstration analogous with that of the reflex frog, it would be necessary to find some way of *psychically* decapitating the rat, while leaving the spinal cord intact.

the vigorous brushing movements when a disagreeable olfactory stimulus is applied; but the first attempts at face washing I have noticed—and I have observed several litters with respect to this point—are not earlier than the tenth day. The other instinctive activities readily lend themselves to similar analysis.

Huddling. One of the most striking and characteristic activities of the young rats is that of huddling and piling up together. Of course this is a manifestation of the need of the organism for warmth. That indeed is their first need. They can endure a day of fasting much better than they can endure an hour of existence in a temperature of 40°. After birth they are immediately drawn under the mother's abdomen, where they are kept in a comparatively high temperature. Whenever the mother is removed or they are themselves taken from the nest, they immediately seek to pile up in a compact heap.

I am led to ask whether this is not one of the roots of the social instinct. I think it is by no means a new idea that the desire for warmth has been a factor in socialization; so there is no heterodoxy in the suggestion. This constant desire—imperative need—for warmth, drawing the animals into such intimate physical contact cannot fail to provide a basic social bond. As a matter of fact the adult animals retain the habit. Except in the very warmest weather a cage full of rats will always be found in a compact heap when at rest.

Play. The first distinct case of play I have noticed occurred on the eighteenth day, when I saw the young rats apparently hiding from each other in the excelsior of the nest; but before that time, there were anticipations of play activities in climbing, running, gnawing, etc. The development of the play activities was exceedingly rapid after this first case. On the nineteenth they were running constantly about the cage, climbing over each other and making occasional sallies at the loose excelsior. On the twentieth, they were chasing each other and I saw one tugging at another's tail. On the twenty-second, I saw them biting each other in play. By the twenty-fifth, their whole repertory of plays was complete: running, jumping, climbing, fierce sham fights (no anger ever), with biting, clawing and pommeling, running over the mother and biting her ears, digging in corners, gnawing at the cage, sex-motions, "picking," licking and fondling each other. Most of their playing is violent—frantic dashes up the sides of the cage, sudden leaps into the air, violent assaults upon each other. I have not made out whether all the play activities are definitely anticipatory—according to Groos's theory. My catalogue of plays is far from complete. It would be instructive to work from the other end, by making a complete catalogue of adult activities, and compare this with a

similar catalogue of infant play activities. It would be hard to get them all under Groos's blanket of anticipation, unless it be stretched rather beyond Groos's own usage. By making the law of selective utility of very broad generality, so as to include the general well-being induced by play as a factor of selective utility, one may make play fall under the domain of natural selection; but it is by no means evident that all the specific play activities of infancy are immediately and definitely propædeutic to specific necessary activities of maturity. It would be surprising, too, in this particular case if there were not found in the plays survivals of wild traits that are of no possible utility in their present mode of life. It is not improbable that some of the plays are mere kinetic equivalents for previous highly useful functions, the rudimentary organs of which persist in the infant organism. The subject of play is so new and so little exploited from the inductive side, that some important results ought to follow a careful study of the ontogenetic development of the play activities.

AFFECTIVE STATES. From the very first, the young rats give evidence of experiencing feelings of general bodily discomfort, hunger, and pain. On the pleasurable side, they show signs of satisfaction when hunger and the desire for warmth are satisfied. Other emotional psychoses were manifested at later successive times.

Fear. The evidence of any fear psychosis, before the eyes and ears began to function, is not unequivocal. Before this, there were noted frantic efforts to recover disturbed equilibrium, violent reactions to sudden tactal stimulations and signs of disquietude when the rats came to the edge of the table, or when they were suspended from the finger. These reactions, however, are largely reflex, so it is impossible to say how much emotional significance they have. In view of the most satisfactory theories of emotion, the presumption is strong that there is an emotional accompaniment; at least, that there are organic disturbances, which are basic, physiologically, to emotional psychoses. On the other hand, it was quite clear that there was no instinctive fear of their natural enemies, mediated by the sense of smell, before the eyes and ears were open. The young rats showed not the slightest symptom of fear either of man or of cat, though I tested them almost daily by my own presence and by presenting my hand to their noses after having impregnated my hand with cat-odor by rubbing a cat. This fact is interesting in view of the opinion so generally held that animals with a keen sense of smell have a congenitally instinctive fear of their natural enemies. This is the more striking in the case of the rat, since his olfactory apparatus is extraordinarily well developed at birth. It must be assumed, how-

ever, that no instinctive fear exists. On the contrary, adult rats that have had no experience with cats show some uneasiness at the cat-odor. What the facts do seem to indicate is that the manifestation of instinctive fear waits upon the integration and functioning of the higher centers. An occurrence noted upon the same day the eyes and ears opened suggests to me that there may be an acceleration or consummation of this process simultaneously with the advent of these two senses. Before this time, handling of the rats had elicited no symptom of fear. On this occasion, however, one of the rats, when I put my hand into the nest and touched him from behind, ran hastily out of the nest. The significance of this action lies in its close simulation of the action of adult rats under like circumstances; they always show fear when touched suddenly from behind, but little or none if approached from before. If such an acceleration of development does take place at this time, it is not necessarily dependent upon the experience gained through these new sense avenues; the example cited could not be referred to any such experience, but must rather be referred to the functioning of the higher cerebral centers. It is patent, however, that after the functioning of the ears and eyes the fear field is immensely broadened, and becomes more specifically psychic.

Other specific emotions appear later. The pleasurableness of bodily comfort apparent in the first few days of life becomes positive joy when the neuro-muscular development permits of free and well co-ordinated movements—about the time of the opening of the eyes and ears. No case of anger was observed until very much later—not earlier than six or seven weeks. In all the tussling and fighting during play I have not seen a single rat lose his temper and “go at it in earnest.”

Something like an altruistic sentiment is apparent in the mutual service which the young rats perform for each other by licking and “picking” vermin. I have recently seen adult rats tenderly lapping the eyes of sore-eyed mates. I think there is a considerable fund of altruism in the rat nature, in spite of the fact that they eat each other when very hungry—starving men do that!

CURIOSITY. As fear or timidity is the most striking of the emotional traits of the white rat, so is curiosity, of the *intellectual* traits. The premonitions of curiosity are to be seen in the restlessness of the young rats as soon as they are able to move freely. By the time they are three weeks old it is inordinate and overbalances fear. It is really curiosity, which is customarily spoken of as boldness by writers upon the natural history of the rat. Unless the rats happen to become special pets, their adult psychic life is a pretty even oscillation between these two states. Their curiosity is not entirely a matter of the stomach,

either. It may be supposed that a large part of their inquisitiveness is in the service of nutrition; but the biological necessity of safe surroundings is not less imperative. There is certainly a double root to this trait.

INTELLIGENCE. Upon this point there is little to be said. If we take intelligence in its objective, biological or teleological sense, *i. e.*, the power of the organism to adapt itself to new environment, the development of intelligence in these first four weeks is readily followed. At birth we see a larval organism, endowed with slight power of movement, insufficient to secure food and warmth, or to avoid danger, insensitive to all external excitations except temperature and odors, endowed with no psychic life beyond desire, and pleasure and pain. Gradually we see this organism change from its larval appearance to a form indicative of energy and activity. As the neuro-muscular system develops, all those instinctive activities so necessary to life appear one by one; and with the anatomical and functional development of the several sense-organs, advances, *pari passu*, the sensational horizon. The repertory of motor and emotional instincts, functional and psychic traits is rapidly filled out; and at the end of the fourth week of life, we have the young rat in full possession of that power to learn by experience, to seek out advantageous things, and to avoid dangerous things, which we call intelligence. Little would be gained here by attempting to resolve any specific process of intelligence into its elements. The one case of imitation noted is an example: the young rat saw the mother doing a certain thing and did it himself. The most obvious explanation of this process is that the visual image of what the young rat saw touched off a motor impulse resulting in similar action; but the explanation is superficial—it fails to touch the most important part of the question—how the visual image connects with the motor image, or impulse. Similarly, the complex mental process involved in the action of the rat that pushed his fellow away from a dish of milk in order to have free access himself, could receive only a superficial explanation in associational terms.

Finally, the chief value of a study of this kind is not in the analysis of the intellectual processes, valuable as that may be, but rather in getting a picture of the psychic make-up of the animal—an insight into his character through an appreciation of his fundamental psychic traits, which persist with undiminished vigor through the vicissitudes of an environment different in all its factors from that of the free wild life in which his psychic nexus was woven in the loom of necessity.